Multi-Grid Probe for Glow Discharge Plasma Analysis

By Zachary Zembower
Supervisor: Dr. Vladimir Gorokhovsky
Consultant: Professor Svetlana Avtaeva
Colorado School of Mines, Physics Department
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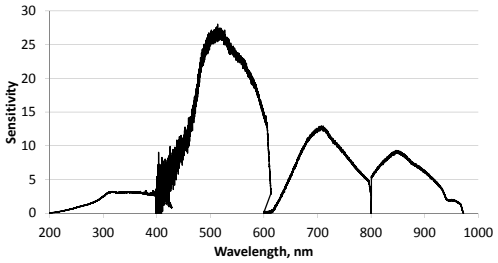
Goals

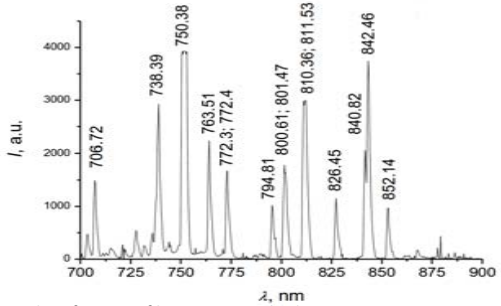
- Develop a technique for determining energy distribution of ions in plasma and discharge parameters
- Develop software for data acquisition and analysis
- Test it against other proven techniques
- Cost effective alternative to mass/energy analyzer
  - Costs >$150,000
- Find correlation between spectral line intensities

Spectroscopy

Sensitivity Calculation

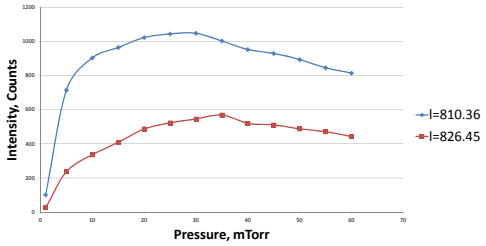


- Took spectra from NIST certified Deuterium lamp DH-2000
- Calculated polynomial from NIST data
- Compared actual spectra to NIST certified data
- Same procedure for tungsten halogen lamp in visual range

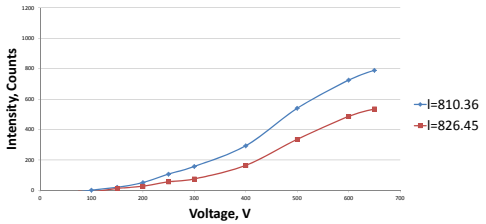


- Identification of lines in a standard spectra
- Full spectra covers the range between 200-1000nm
- Recognition is an ongoing process

Pressure Response, Voltage = 300V

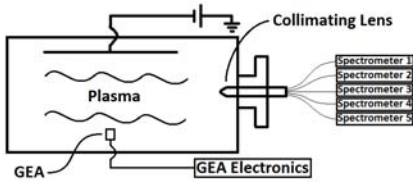


Voltage Response, Pressure = 10mTorr



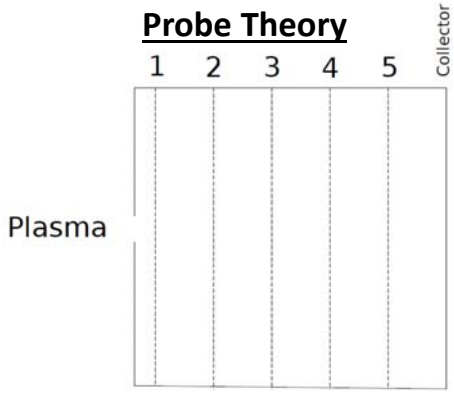
- Changing voltage under constant pressure
  - •Intensity increases with voltage
- Changing pressure under constant voltage
  - •A maximum is observed at 30mTorr
- Assume excitation of Argon atoms is direct electron impact
  - Good for pressures below 30 mTorr
  - More complex behavior
    - Due to many more elementary processes
    - In addition to direct electron excitation

Experimental Setup



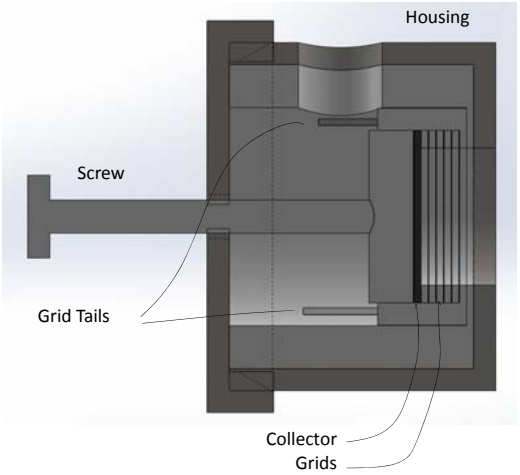
- 4 precise spectrometers ranges
  - 200-400nm
  - 400-600nm
  - 600-800nm
  - 800-1000nm
- 1 broad spectrometer for 400-1000nm range

Probe Theory



- Plasma enters through small hole
- First grid is grounded
  - Separates probe from plasma
  - Protects plasma from perturbation
- Second grid is below ground
  - Filters out primary electrons
- Third grid is swept through a potential range
  - Filters out ions that are below that energy level
- Fourth grid is grounded
  - Sets a reference potential for the collector
- Fifth grid is below ground
- Filters out secondary electrons emitted by third grid
- Collector is grounded or negatively biased
  - Helps collection of ions
- The derivative of the graph is taken to show the ion energy distribution function (IEDF)

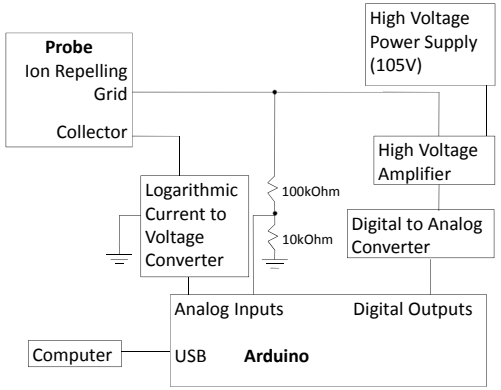
Probe Design



Cross section of probe in SolidWorks

- Screw holds tension on grid assembly
- Grids are stainless steel
  - •Have tails to allow soldering to wires
- Collector is graphite
  - •Has grid behind it to allow for easy connection
- Housing is stainless steel
- Everything else is PTFE
- Hole in side for wires to run to chamber wall

Electronic Schematic



- Arduino sets an 8-bit number through digital outputs
- Digital to analog converter converts 8-bit number to
- a voltage between 0-5 V
- High voltage amplifier amplifies voltage between 0-105 V
- Series of resistors drops voltage back to the range 0-5 V
  - Arduino reads 0-5 V
- Ion repelling grid is charged to high voltage set point
  - Filters out ions
- Collector collects remaining ions
  - Generating a small (pA-mA) current
- Logarithmic current to voltage converter converts
- current to voltage
  - Voltage is scaled internally to 0-5 V range
- Arduino reads the voltage
- Arduino sends data to computer running MATLAB over USB
- Arduino iterate through next 8-bit number

Physical Probe

Future Work

- Calculate concentration of different species from spectra
- Determine electron temperature from spectra
- Compare results with Langmuir probe
- Test GEA in glow discharge environment
- Finish computer interface
- Allow for real time updates from probe